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NASA'S UNIQUE PERSPECTIVE ON EARTH

Many people associate NASA with astronauts, Mars and the moon, but the agency is also a world leader in conducting breakthrough research on the most important scientific questions about our home planet, Earth.

Earth is a complex, dynamic system interconnecting air, land, water, ice and life. The Earth system is constantly changing on all scales of space (ranging from local to regional to global) and time (from short-term events like weather, to longer-term processes such as climate change and movement of Earth's plates).

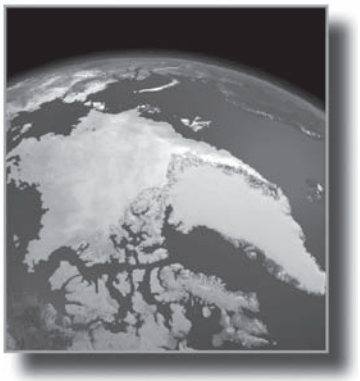
NASA has a unique capability to gather global data using satellite, aircraft and ground observations. These observations—together with advanced data analysis tools and computer models—help scientists advance their understanding of the Earth system and its response to natural and human-caused environmental changes.

Two fundamental questions drive NASA's Earth science research:

1) *How is the global Earth system changing now?*
2) *How will the Earth system change in the future?*

To answer these questions, NASA conducts research on the following key science areas:

- **Atmospheric composition**—Changes in the relative proportions of the different gases found in the atmosphere have important consequences for the Earth system. The Earth's energy budget changes in response to increases in greenhouse gases as well as particulates and aerosols in the atmosphere. This in turn forces changes in our climate system, as well as affects air quality.
- **Climate variability and change**—A unique NASA contribution to climate science is the vast amount of Earth observations made from space, using satellites. Ice sheets, sea ice, sea level, clouds, snow cover, solar radiation and humidity are all routinely monitored from satellites. These observations help us to understand the interactions and feedbacks between different parts of the Earth system and how they contribute to our climate.
- **Water and energy cycles**—Solar energy drives the water cycle. NASA is studying the distribution, transport and transformation of water and energy within the Earth system. Understanding the water cycle also plays a critical role in forecasting changes in the frequency and intensity of floods and droughts.
- **Carbon cycle and ecosystems**—NASA helps to characterize and quantify the movement of carbon between the atmosphere, life, land and ocean, as well as monitor atmospheric concentrations of carbon dioxide and other key carbon-containing gases and aerosols.
- **Earth surface and interior**—NASA science research is furthering our understanding of solid Earth dynamics. This knowledge is also being used to predict, prepare for and respond to natural hazards, including earthquakes, landslides, coastal and interior erosion, floods and volcanic eruptions.
- **Weather**—Satellite observations allow us to understand the dynamics of the atmosphere, the ocean and the land surface, and how their interactions generate weather.



Finding answers to the fundamental science questions about the Earth system is of great benefit to society. In addition, there are immediate and practical applications of NASA's Earth science data, scientific knowledge and technology. These include tracking diseases, aviation safety, locating and using energy sources, monitoring air and water quality, evaluating risk, and preparing for and responding to natural disasters.

Top image: *Approaching the 2011 Arctic sea ice minimum. Credit: Scientific Visualization Studio at NASA Goddard Space Flight Center.*
Bottom photo: *Dr. Laurie Leshin exploring in Antarctica. Credit: NASA.*

WHERE CAN YOU FIND EARTH SCIENTISTS?

The work of Earth scientists at NASA and elsewhere directly impacts our lives. Many people who study Earth science go on to become atmospheric scientists, chemists, geologists, oceanographers, marine biologists, meteorologists, and more.

Besides careers as scientists, people with a background in Earth science can also be found working in:

- Agriculture
- Art
- Computer programming
- Education
- Engineering
- Environmental planning
- Filmmaking
- Graphic design
- Journalism
- Museum curating
- Policy making
- Website development

Learn more about these jobs at:
http://climate.nasa.gov/esw2012

Clouds display at the 2011 Explore@ NASA Goddard event. Credit: NASA/ GSFC/Bill Hrybyk.

WHO ARE NASA EARTH EXPLORERS?

Earth explorers come from a variety of backgrounds and help NASA study the Earth in many different ways. They are scientists, engineers, computer programmers, and more. The complete collection of full-length articles is available at • ***http://climate.nasa.gov/esw2012***

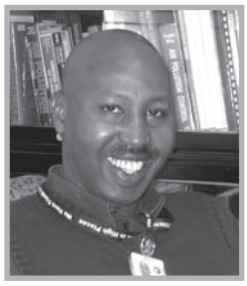


Photo: NASA

Ali Omar ■ Ali Omar knows how to keep his head in the clouds. After watching aircraft take off and land near his high school, Omar decided that he wanted to design and build airplane engines. Although he majored in aeronautical engineering in college, he later found himself on a different career path. Omar is now an atmospheric scientist, studying surface radiation as part of NASA's CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) team. "I am glad I did not pursue a career in aviation because I really enjoy my work as an atmospheric scientist," Omar says.

Photo: NASA

Brian Kahn ■ Weather has fascinated Brian Kahn since he was a child. He filled notebooks with data he collected about local temperature, humidity and wind speed. Choosing a career was easy for Kahn. After studying meteorology, he went on to receive a PhD in atmospheric science. Now as part of NASA's AIRS (Atmospheric Infrared Sounder) mission, Kahn continues to learn about the Earth's weather patterns. The data from AIRS helps Kahn create three-dimensional maps of clouds, temperature, water vapor, and more. "I spend a lot of time thinking and daydreaming about my work," Kahn says. "So, don't ever let anyone tell you that daydreaming is a waste of time."

Photo: NASA

Carl Magnusson ■ Growing up in western Oklahoma, Carl Magnusson was drawn to the skies at an early age. A U.S. Air Force veteran, Magnusson was a KC-135 instructor pilot before joining NASA's Airborne Science Program. Now flying on the DC-8 flying laboratory, Magnusson supports Earth science missions all over the world as a navigator. He works with the pilots, ground crew and scientists to insure that the maximum amount of science data is collected. Polar ice missions, hurricanes, forest fires: Magnusson has flown with NASA all over the globe. "The best part of this adventure is the people," Magnusson says. "I'm a lucky guy and I love coming to work!"

Photo: NASA

Carmen Boening ■ As a teenager, Carmen Boening loved watching science documentaries, but she did not plan to be a scientist, majoring in mathematics and computer science in college. On a research cruise to Antarctica, she began studying ice sheets and decided to become an oceanographer and climatologist. As part of NASA's GRACE (Gravity Recovery and Climate Experiment) team, Boening uses satellite gravity measurements of the Earth to "weigh" earth system components like ice sheets and track the movement of water across the surface. "Being on the ocean and seeing the fascinating landscape of Antarctica made me want to learn more about our planet," Boening says.

Photo: Steve Graham

Claire Parkinson ■ As a scientist studying sea ice and climate in the Arctic and Antarctic regions, Claire Parkinson understands the complexity of Earth. Parkinson did not expect to be an Earth scientist: her degree is in mathematics. But her mathematical and analytical skills prepared her well for analyzing satellite data as part of NASA's Aqua satellite team. Interpreting that data is never simple. "We are bound to discover in the future that some of our current understandings are flawed in one way or another," Parkinson says.

Photo: Gene Feldman

Gene Feldman ■ The oceans have always been part of Gene Feldman's life, from early memories fishing with his grandfather to his time caring for sea turtles at a Samoan turtle hatchery. Spending time on the ocean, Feldman wondered why some parts of the ocean were more productive than others. This question drove his career, leading him first to get his PhD in oceanography and eventually to study the oceans at NASA. Feldman uses NASA satellites to collect data about ocean color and learn more about the role the oceans play in global change. As project manager for the Aquarius satellite, he works as part of a team studying sea surface salinity and how the oceans take in carbon dioxide. "It always amazed me that there's all of this stuff beyond what we can see, down below the surface of the water," Feldman says.

Photo: NASA

Graeme Stephens ■ The clouds that Graeme Stephens studies as head scientist for NASA's CloudSat mission are also the prime subject of his work as an artist. Stephens studied meteorology in college. He not only uses that science in his job, but it also has a bearing on his paintings of sky landscapes. "Art and science have much in common. And much has been written about the common threads between both," Stephens says. "Both, after all, are different expressions of the natural world around us."

Photo: NASA

Jeff Masek ■ Most scientists do not start college as history majors, but Jeff Masek did. Masek planned to major in archeology but after realizing that history is written in the earth itself, he switched to geology. He is now a biospheric scientist working on the Landsat mission, mapping vegetation dynamics with satellite data. He continues to use his knowledge of history to study how landscapes have changed. "There is a feeling of accomplishment when you learn something new about the Earth that nobody has discovered or measured before," Masek says. "Those sorts of *A-ha!* moments are really rare, but extremely rewarding."

Photo: NASA

Jessica Taylor ■ When Jessica Taylor was growing up in Florida, she was fascinated by storms and the flashes of light that accompanied them. She has since come to realize that different things drive people to science. As education and public outreach lead for NASA's CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) satellite and a lead trainer for the GLOBE (Global Learning and Observations to Benefit the Environment) education program, Taylor looks for ways to connect students with science and get them enthusiastic about it. She knows that she has become a role model for many students and takes that responsibility seriously. "There's always that possibility that something you do or something you say will drive that spark," Taylor says.

Photo: NASA

Kelly Teague ■ Rainy days spent asking her father science questions put Kelly Teague on the path to becoming an Earth explorer. With a strong background in physics and computer programming, Teague now works as a flight software engineer for NASA's CERES (Clouds and the Earth's Radiant Energy System) instruments. She is responsible for writing the code that tells the instruments how to operate. Her passion for asking questions led her to design a new way for one instrument to operate. "I'm not entirely certain, but I don't think that has ever been done before," Teague says. "It was kind of cool, the idea that I can make an instrument do something that it was never designed to do."

Photo: NASA

Marc Imhoff ■ Marc Imhoff did not expect to find himself in a tiger preserve setting up instruments when he first started working for NASA. His career began with monitoring global crops using satellites. Now, as the project scientist for NASA's Terra satellite mission, he actually travels to the sites where the science supported by Terra is being done. It was his work on flood mapping that took him into the jungles of India and Bangladesh. The instruments he set up in the preserve were part of a radar imaging experiment being done by the astronauts on the space shuttle. "We discovered how to map floods right through clouds and even under trees," Imhoff remarks.

Photo: NASA

Mark Fujishin ■ Growing up, Mark Fujishin was fascinated by anything that flew. So it seems logical that he should find himself in a career working with NASA satellites. As project manager for the Jason satellite, Fujishin collaborates with other members of the satellite mission operations team to keep the satellite functioning well and transmitting data to Earth. "My hope is that the information and discoveries enabled by these satellites will help the Earth's governments and societies understand better how they can keep the planet healthy and productive," Fujishin says.

Photo: NASA

Susan Thomas ■ From lightning to prisms, Susan Thomas has been interested in the properties of light since she was young. As the lead instrument scientist on CERES (Clouds and the Earth's Radiant Energy System), Thomas now uses light—both visible light and radiation—to not only learn more about how the Earth reflects sunlight and emits its own radiation, but also to better understand the role clouds and the energy cycle have in climate change. "Every scientific finding—whether it be a new technology or a solution or evaluation of an ongoing problem—has the potential of greatly impacting the world around us," Thomas reminds us.

Visit • ***http://climate.nasa.gov/esw2012*** • for links to full-length articles about the explorers above and to learn more about these Earth explorers (from left to right):

Photos: #1, 2, 4, 5, NASA; #3, Luigi Boschetti

- **Erica Alston**—Motivated to protect the natural beauty of the world, Alston is a computer engineer who works on air quality issues at NASA's Langley Research Center.
- **Cynthia Rosenzweig**—A research scientist with the Climate Impacts group at the Goddard Institute for Space Studies, Rosenzweig focuses on how climate impacts systems and sectors important to human well-being.
- **Chris Justice**—A tenured professor at University of Maryland, Justice is a geographer who uses data from NASA satellites to create visual maps of global fires.
- **Wei Zhang**—Originally from Shanghai, Zhang is a software test engineer for the Atmospheric Sciences Data Center at NASA Langley Research Center, responsible for correcting any defects in the software she works with.
- **Garfield Creary**—As lead mechanical engineer for NASA's Stratospheric Aerosol and Gas Experiment (SAGE) III project, Creary uses 3D models and other physical representations to help people understand how SAGE III works.

earth explorers

WORKING WITH NASA DATA: ONE TEACHER'S STORY

Photos: Gary Popiolkowski

Gary Popiolkowski has been using NASA resources and programs in his middle school classroom for over a decade. His involvement began when he attended a workshop at West Chester University in August 1995. This workshop provided him with the training necessary to engage his students in The GLOBE Program. GLOBE (Global Learning and Observations to Benefit the Environment) supports students, teachers and scientists working together on inquiry-based investigations of the environment. "GLOBE offers so much and requires so little," Gary says. "There is so much to select from as far as activities, science projects, field campaigns, background information and data manipulation. It allows the teacher to pick whatever they feel comfortable doing or what they can match with their curriculum/standards."

For the last ten years, Gary and his students have also been involved with a NASA project called S'COOL, or Students' Cloud Observations Online. The S'COOL Project engages students in real science. Students make and report ground truth observations of clouds to help validate NASA's CERES satellite instruments. "My students enjoy going outside and they really enjoy seeing how close they match the satellite view of our area," Gary explains. "They think it is especially cool to help out the scientists with their observations."

Gary also frequently uses the website MY NASA DATA to create activities and labs for his students. He combines the actual NASA data archived on the website with student observations, challenging his students to find the story the data is telling.

"There's some kind of story the data's trying to tell us," Gary says, "and we've got to try and figure out what that is."

Collecting and working with real data gives students a sense of ownership, Gary says. "They can see it's actually happening, and it gives them a sense that they can do some of the same kinds of things that scientists do." Students are able to imagine themselves as Earth scientists and better understand what a career in Earth science could be like.

"Students can see it's not just numbers or graphs—it's a story they're part of. They get to go outside and make observations themselves. It's like they're working with the scientists even though they're far apart."

Gary admits that the amount of materials available can seem overwhelming at first. "Try something small and build from there," Gary advises. "NASA has so many people working in different fields and areas of Earth science. No matter what area you need to cover in your classroom, there's NASA material available to help you do it. You just have to search for it." The MY NASA DATA website has a collection of lessons educators can use and adapt for their students.

Gary Popiolkowski and students Aliyah, Mateo, Carly, and Jordan use S'COOL resources to identify clouds. Credit: Gary Popiolkowski.

Learn more about the programs Gary Popiolkowski uses in his classroom by following these links:

MY NASA DATA
- *https://mynasadata.larc.nasa.gov*

NASA CERES S'COOL (Students' Cloud Observations Online) Project
- *http://scool.larc.nasa.gov*

GLOBE (Global Learning and Observations to Benefit the Environment) Program
- *http://globe.gov*

GLOBE Program Teacher Workshops
- *http://classic.globe.gov/fsl/workshop/registration.pl*

"Cloud Study Investigators: Using NASA's CERES S'COOL in Problem-Based Learning." Article written by Gary Popiolkowski and Susan Moore, published in the NSTA journal *Science Scope* in July 2011 • *http://bit.ly/rtFJPv*

EDUCATION STANDARDS

AAAS Benchmarks for Science Literacy

The articles highlighted on this poster support the following science content standards (*AAAS Benchmarks,* 2009):

Grades K–2:

- Everybody can do science and invent things and ideas. 1C/P1
- In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean. 1C/P2

Grades 3–5:

- Science is an adventure that people everywhere can take part in, as they have for many centuries. 1C/E1
- Doing science involves many different kinds of work and engages men and women of all ages and backgrounds. 1C/E3

Grades 6–8:

- Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times. 1C/M1
- Scientists are employed by colleges and universities, business and industry, hospitals, and many government agencies. Their places of work include offices, classrooms, laboratories, farms, factories, and natural field settings ranging from space to the ocean floor. 1C/M4

Grades 9–12:

- Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some subdisciplines spin off to become new disciplines in their own right. 1C/H4

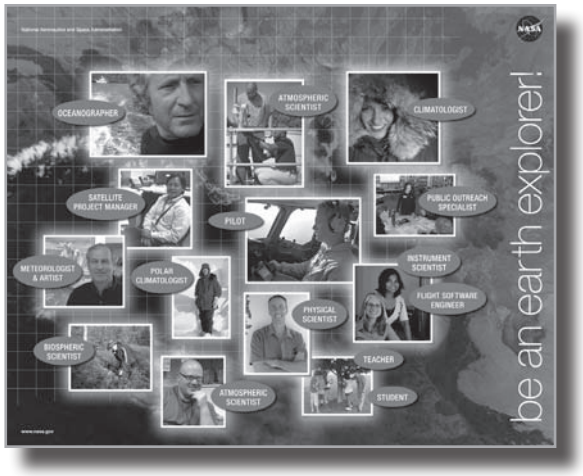
Next Generation of Science Education Standards

The National Resource Council's *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* emphasizes science and engineering practices along with such crosscutting concepts as cause and effect, stability and change, systems, and patterns. The careers discussed on this poster and on the website can help students become familiar with those practices and concepts.

Download this poster as a PDF file at ***http://climate.nasa.gov/esw2012***

Center photo: *Dr. Elena Sparrow, University of Alaska Fairbanks, working with GLOBE students. Credit: GLOBE.* ***Bottom photo:*** *Dr. Marshall Shepherd, formerly NASA GSFC (now University of Georgia), talks about NASA's role in understanding hurricanes, using the Tropical Rainfall Measuring Mission. Credit: NASA Goddard Photo and Video.*

CLASSROOM APPLICATIONS OF THIS POSTER



Be sure to find wall space in your classroom that is highly visible and easily accessible to display this official Earth Science Week poster—you will want to refer to it often throughout this school year!

As you engage in Earth Science Week activities, both from this packet and from other resources, remind students that the work done by the people in these careers has changed and continues to change science, the world, and our lives. The activities listed below and at • ***http://climate.nasa.gov/esw2012*** • will show the impact of these careers, and will convince students that they, too, can become Earth explorers.

The content of this poster applies to many academic areas; examples are included below. Beyond the obvious alignment with the science content and careers found in the *AAAS Benchmarks for Science Literacy,* the content is also easily tied to language arts and current events.

Below are several suggestions for incorporating this poster into lessons throughout the school year. These activities not only complement the poster—they could inspire the next generation of Earth explorers!

Alignment to Benchmarks for Science Literacy

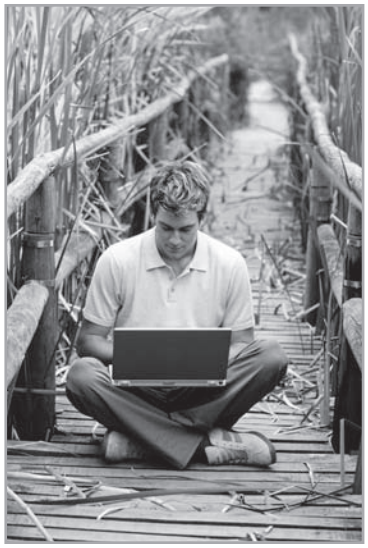
A discussion of science careers appears in Chapter 1 of the *AAAS Benchmarks.* Found under subsection 1C, "The Scientific Enterprise," is the following narrative (condensed here from the narrative prefacing grade 3 through grade 12 *Benchmark* statements):

> *"Career information can be introduced to acquaint students with science as an occupation in which there is a wide variety of different kinds and levels of work. Teachers should emphasize the diversity to be found in the scientific community: different kinds of people (in terms of race, sex, age, nationality) pursuing different sciences and working in different places (from isolated field sites to labs to offices). Students can learn that some scientists and engineers use huge instruments (e.g., particle accelerators or telescopes), and others use only notebooks and pencils. And most of all, students can begin to realize that doing science involves more than "scientists," and that many different occupations are part of the scientific enterprise…Teachers should continue to seize opportunities for introducing information on science as a diverse line of work. Above all, children in early adolescence need to see science and science-related careers as a real option for themselves personally."*

Members of the 2008 GLOBE Learning Expedition in Cape Town, South Africa, head out on a coastal trail to explore the environment at Cape Pointe at the Cape of Good Hope, in Table Mountain National Park. Credit: GLOBE.

Content *Benchmarks* directly related to the careers of the poster's Earth explorers are found in Chapter 3, "The Nature of Technology"—and Chapter 4, "The Physical Setting."

Have the students research, discuss and/or role play how a career featured on the poster may have contributed to the knowledge—or will contribute to further knowledge—on the *Benchmark* topic.



Dr. Eric Brown de Colstoun working with a student during Goddard Middle School Week 2010. Credit: NASA.

For example, Chapter 4, Section 4C/E1, states that by the end of 5th grade a student should know that, *"Waves, wind, water, and ice shape and reshape the Earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers."* Ask your students to investigate the answer to the question: How would an atmospheric scientist, computer programmer, chemist, engineer, geologist, meteorologist, and/or oceanographer have contributed to the knowledge?

At the high school level, have students research the practical aspects of each career—to include college preparation (colleges offering the major, course work required, degrees offered, internships/fellowships available), employment opportunities (employers, pay ranges, degrees and experience recommended/required), and individual and organizational leaders in the field. If possible, have the students contact someone in the local area whose career is featured on the poster. Students could interview that person, job shadow him/her, or arrange for a "career day" appearance in the classroom.

Current Events

Subscribe to e-mail updates or bookmark the following NASA sites:

- ***http://earthobservatory.nasa.gov***
- ***http://climate.nasa.gov***

Check these sites often for the latest in Earth science research and discoveries. Watch for articles/reports on TV or in newspapers/magazines that feature Earth science. Such current events not only stimulate excitement and discussion about Earth science, they can be used to explore related careers.

Investigate and discuss the connection between the event and a career. While referring to the poster, ask students "Which of the careers on this poster might have had a role in this research or discovery? What role would this career have played? How did this career contribute?" Discussion could include such contributions as gathering data, analyzing data, making that data accessible to the public, or even using data (i.e., a forest ranger).

Integration with Language Arts

Science careers are a logical conduit for addressing certain language arts learning standards. The Earth explorers careers are most easily integrated with those standards that focus on writing and non-fiction reading.

As a writing assignment, have students respond to the following prompts:

- If you could have your ideal career at NASA, what would you want to do and why?
- If you could job shadow one of these careers at NASA, which would you choose and why?
- Compare and contrast two careers featured on this poster.
- Design a project on which three of the featured careers would work together.
- You were awarded a large grant to study climate change in your geographic area. You can hire three Earth scientists to work on the grant. From the careers featured on the poster, which three Earth scientists would you hire and why?

As a reading assignment, have students read a book in which the career is highlighted or examined, or played a role. Students could do this as a "book talk," open reading book choice, written follow-up assignment for science or language arts class, oral follow-up assignment for science or language arts class, or simply as a personal reading choice.

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COVER PHOTO CREDITS

Portraits, left to right: *Row 1: #1 Gene Feldman, #2 & 3 NASA; Row 2: NASA; Row 3: #1, 3 & 4 NASA, #2 Elizabeth Arnold; Row 4: #1 & 2 NASA, #3 Gary Popiolkowski.*

Background satellite image: *The Nabro volcano explosion in Eritrea on June 12, 2011. NASA Earth Observatory image by Robert Simmon, using EO-1 Advanced Land Imager (ALI) data. http://1.usa.gov/JH3gWc*

Top photo: *In the NASA-sponsored Signals of Spring program, middle and high school students use satellite data to investigate migration patterns of land and marine animals. Credit: Signals of Spring.* ***Bottom photo:*** *Undergraduate research in ocean and marine science at Elizabeth City State University, NC. This team is collecting and testing Pasquotank River water samples. Credit: ECSU Center of Excellence in Remote Sensing Education and Research (CERSER).*

earth explorers

Learn aboout teacher workshops, events and class resources at ***http://smdeponews.org***

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